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#15/Appeal Brief
Hawkins
3/13/02

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Swarn S. Kalsi	Art Unit	:	2834
Serial No.	:	09/371,692	Examiner	:	G. Perez
Filed	:	August 10, 1999			
Title	:	SUPERCONDUCTING ELECTRIC MOTOR			

BOX AF
Commissioner for Patents
Washington, D.C. 20231

BRIEF ON APPEAL

Applicant appeals the final rejection of claims 1-22 in the final action dated May 31, 2001. A notice of appeal was filed on October 31, 2001.

Applicant requests that the rejection of claims 1-22 be reversed.

(1) REAL PARTY IN INTEREST

The real party in interest is the American Superconductor Corporation, a Delaware corporation having a place of business at Two Technology Drive, Westborough, Massachusetts as evidenced by an assignment executed October, 17, 2001 and submitted for recordation at the U.S. Patent Office on October 24, 2001. The reel and frame number are unavailable as of the time of filing this appeal brief.

(2) RELATED APPEALS AND INTERFERENCES

Neither Applicant, nor Applicant's legal representative, nor the assignee are aware of any appeals or interferences that will directly affect or be affected by or have a bearing on the Board's decision in the pending appeal.

(3) STATUS OF CLAIMS

Applicant filed the present application on August 10, 1999 with claims 1-22. Of these, claims 1, 17 and 21 are independent.

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In the final office action, the Examiner rejected independent claims 1 and 21 as being rendered obvious by the combined teachings of *Rabinowitz*[1] and *Higashi*[2]. In particular, the Examiner considered that the superconducting bulk material of the *Rabinowitz* rotor taught Applicant's claimed superconducting winding.

The Examiner concedes that *Rabinowitz* fails to teach a rotor assembly having induction structure for carrying current at levels sufficient to allow operation in the steady state induction mode. The Examiner asserted that *Higashi* taught a rotor assembly having this property and that it would have been obvious for one of ordinary skill in the art to replace the *Rabinowitz* rotor assembly with the *Higashi* rotor assembly. As motivation to combine for this replacement, the Examiner proposed that doing so would improve the efficiency of the motor.

The Examiner rejects claim 17 as being rendered obvious by the combined teachings of *Rabinowitz, Higashi* and *Renard*[3]. The Examiner acknowledges that the combination of *Rabinowitz* and *Higashi* does not teach a cryostat but that *Renard* does. As motivation to combine the *Renard* cryostat with the combination of *Higashi* and *Rabinowitz*, the Examiner suggests that doing so would maintain the superconducting winding at cryogenic temperatures.

On October 31, 2001, Applicant appealed from the rejection. A copy of the claims pending in this appeal is attached as Appendix I.

(4) STATUS OF AMENDMENTS

On July 31, 2001, following the final rejection, Applicant filed a request for reconsideration. The request for reconsideration did not present any claim amendments. In an advisory action mailed on August 22, 2001, the Examiner maintained his rejection of the claims.

Applicant last amended the claims in a response to the non-final office action of July 5, 2000. These amendments have been entered.

(5) SUMMARY OF INVENTION

Applicant has invented a superconducting electric motor that includes a rotor assembly. The rotor assembly includes a support winding for supporting a superconducting winding which,

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[1] *Rabinowitz*, et al. U.S. Patent 5,325,002.

[2] *Higashi*, U.S. Patent No. 4,885,494.

[3] *Renard*, U.S. Patent No. 3,904,901.

in operation, generates a flux path within the rotor assembly. The rotor assembly is configured to operate in a synchronous mode at temperatures below which the superconducting winding exhibits superconducting characteristics and in a steady-state induction mode of operation at temperatures above which the superconducting winding loses its superconductivity.

In one embodiment of the invention, an electric motor **1** switches between synchronous mode and steady-state induction mode.[4] The mode of operation depends on the temperature of rotor windings **30**. These rotor windings **30** are made of a superconducting material.

FIGS. 1 and 2 illustrate this embodiment of the claimed subject matter. These figures show a motor **1** having a rotor assembly **5** that includes a superconducting winding **30**. The superconducting winding **30** is configured such that when current flows through it, the magnetic field that results from that current includes a component that is directed through the rotor assembly. This is the "flux path within the rotor assembly" recited in the claims. A support structure **20** supports the superconducting winding **30** on the rotor assembly **5**.

The rotor assembly **5** is configured to operate in a synchronous mode when the superconducting winding **30** is below its critical temperature. This is achieved by locking the stator magnetic field with the field generated by current in the superconducting winding.[5]

The rotor assembly **5** is configured to operate in a steady-state induction mode when the superconducting winding **30** is above its critical temperature. If the temperature rises to the point at which the rotor windings **30** lose their superconductivity, the rotor assembly **5** will begin to slip relative to the rotating magnetic field generated by current in the stator windings. Because the outermost conductive layer in the rotor assembly **5** would then be exposed to a time-varying magnetic field, current is induced in those layers. The interaction of those induced currents with the rotating stator field causes the motor **1** to operate in induction mode.[6] In the particular

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[4] *Applicant's specification*, page 10, lines 22-24 "To allow continuous, steady state operation in the induction mode...").

[5] *Applicant's specification*, page 9, lines 18-27, ("In operation, superconducting motor 1 is operated in the synchronous mode so that rotor assembly 5 rotates at the same speed as the rotating magnetic field produced by the surrounding stator winding (Fig. 1). In essence, the DC excited fields generated by the superconducting windings 30 are locked in synchronous fashion with the stator magnetic field. In this mode, magnetic field interaction is limited to the stator field and the superconducting winding assembles with virtually no currents induced in the surrounding structure of the rotor assembly.").

[6] *Applicant's specification*, page 9, line 31-page 10, line 9 ("However, if superconducting rotor assembly 5 experiences a cooling failure, winding assemblies 30 would lose their superconducting properties. In this case, superconducting rotor assembly 5 is operated in the induction mode. In the induction mode, rotor assembly 5 rotates

embodiment illustrated in the figures, these induced currents flow on an induction structure formed by the support member **20**, an electromagnetic shield member **14**, and a cryostat **12**.[7]

(6) ISSUES

At issue in this appeal are:

1. Whether *Rabinowitz* and *Higashi*, when combined, teach a superconducting winding.

2. Whether there exists motivation to combine *Rabinowitz* and *Higashi*.

(7) GROUPING OF CLAIMS

Group I: Independent claim 1 and dependent claims 2-16.

Group II: Independent claim 17 and dependent claims 18-20.

Group III: Independent claim 21 and dependent claims 22.

(8) ARGUMENT

***Rabinowitz* teaches away from a superconducting winding**

Rabinowitz teaches a rotor **11** that incorporates superconducting material **12** within its structure. In one embodiment, shown in FIGS. 1 and 2, the superconducting material **12** occupies several disk-shaped slices of the cylindrical rotor, with electrical/thermal conductors **13** separating each slice of superconducting material **12**.

As discussed in more detail below, *Rabinowitz*:

- teaches away from a motor that includes more than one winding, and

- teaches away from a motor that includes a superconducting winding.

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at a speed less than the synchronous speed of the stator field. The relative change between the rotor speed and the stator field generates currents in the surrounding structure of the cryostat 12, electromagnetic shield 14, and cold support member 20.").

7 *Applicant's specification*, page 7, lines 11-15, ("[A]side from their typical functions, cryostat 12, electromagnetic shield 14, and cold support member 20, in aggregate, serve an additional purpose when the synchronous motor no longer operates in a superconducting state"); *Id.* at page 10, lines 4-11 ("The relative change between the rotor speed and the stator field generates currents in the surrounding structure of the cryostat 12, electromagnetic shield 14, and cold support member 20. The currents interact with the stator field to produce shaft torque. Thus, cryostat 12, electromagnetic shield 14, and cold support member 20 must be formed of a material having sufficient mass to generate a sufficient torque to drive the motor in the induction mode.").

Rabinowitz clearly teaches a superconducting motor that includes only a single winding. In the preferred embodiment, the single winding is a stator winding **15**. *Rabinowitz* further teaches that a motor with only a single winding is advantageous because of its simplicity. In particular, *Rabinowitz* states that

> "[b]ecause this motor/generator has *only* a primary set of windings, it is simpler in some ways than most motor/generators."[8]

Thus, far from including a second winding in addition to the stator winding **15**, *Rabinowitz* teaches the undesirability of having more than one winding.

Rabinowitz lists several forms that the superconducting material **12** can take. These forms include particulate, thin-film, foil and bulk superconducting materials.[9] *Rabinowitz*'s omission of superconducting windings from this list is far from inadvertent. In the very next sentence, *Rabinowitz* states that

> "Because it is in a non-wire form, *instead of one or more windings of wire*, the motor/generator can be implemented with substantially any superconducting material, including those that are too brittle to be easily and/or cost effectively formed into superconducting wires."[10]

It is clear from the foregoing that *Rabinowitz* considers superconducting windings to be undesirable because of the difficulty associated with forming superconducting material into wires that can then be wound to form windings. In doing so, *Rabinowitz* expresses a clear preference for *bulk* superconducting materials because such materials can include brittle materials that lack the ductility necessary to be drawn into wires.

The Examiner states that because *Rabinowitz* mentions superconducting windings, there is an implication that superconducting windings are known in the art.[11]

Applicant does not dispute that superconducting windings are known in the art. However, Applicant claims more than just a superconducting winding. Applicant's claimed invention also includes several additional limitations. It is the difference between the claimed invention, including all its limitations, and the prior art that is the proper subject of inquiry in a section 103

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[8] *Rabinowitz* at col. 5, lines 58-60. [emphasis supplied].

[9] *Rabinowitz* at col. 5, lines 64-66 ("The superconducting material can be in any of a variety of forms, including particulate, foil, bulk, and thin-film superconducting materials.").

[10] *Rabinowitz* at col. 5, line 66 to col. 6, line 3, [emphasis supplied].

[11] *Final Office Action*, pages 9-10.

rejection.[12]

In this case, it is clear that *Rabinowitz* perceived the undesirability of incorporating superconducting windings in a superconducting motor. Applicants superconducting motor, with its superconducting windings, is thus contrary to the understanding and expectation of *Rabinowitz*. Accordingly, Applicant's superconducting motor *as a whole* would not have been obvious in view of to those of ordinary skill in the art.[13]

Proposed combination of *Higashi* and *Rabinowitz* changes the principle of operation of *Rabinowitz*

The rotor assembly of *Rabinowitz* includes an electrically conducting torque-shield **14**. Among the functions of this torque-shield **14** is to shield the superconducting material **12** from the stator field. This prevents undesirable heat dissipation within the superconducting material **12**.[14] In addition, the thickness of the torque-shield **14** provides a way to control the slip angle at which the *Rabinowitz* motor makes the transition from a start-up phase, in which it operates in induction mode, to its steady-state synchronous mode.[15]

The torque-shield **14** appears to be a significant component of the *Rabinowitz* rotor assembly. *Rabinowitz* describes the characteristics of the torque-shield **14** at length[16] and also recites the torque-shield **14** in an independent apparatus claim.[17]

The *Higashi* rotor assembly does not appear to include a torque-shield or any structure having the function of the torque-shield. The proposed transplant of the *Higashi* rotor assembly in place of the rotor assembly taught by *Rabinowitz* would thus change the principle of operation

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12 *MPEP* 2141.01 citing *Stratoflex v. Aeroquip*, 713, F.2d 1530 (CAFC 1983) ("In determining the differences between the prior art and the claims, the question under 35 USC 103 is not whether the differences themselves would have been obvious, but whether the claimed invention as a whole would have been obvious").

13 *Schenk v. Nortron,* 713 F. 2d 782 (CAFC 1983) ("Because the insight was contrary to the understandings and expectations of the art, the structure effectuating it would not have been obvious to those skilled in the art").

14 *Rabinowitz*, col. 8, lines 36-38 ("These torque-shields also serve the purpose of shielding the superconducting material from the traveling electromagnetic field. This is done to avoid unwanted heat dissipation within the superconducting material.").

15 *Rabinowitz*, col. 8, lines 48-64 ("The thickness of torque-shields 14 can be tailored with respect to their skin depth such that the electromagnetic fields generated by the stator windings 15 will not penetrate them until the relative frequency (i.e. the "slip") between the traveling wave and the rotating rotor is less than some prescribed value...This value determines the point at which the mode of operation converts from the startup phase induction mode to an operating phase in which it functions in the synchronous mode.").

16 *Rabinowitz*, col. col. 4, line 38-col. 5, line 32, and again at col. 8, lines 24-65.

17 *Rabinowitz*, col. 13, lines 6-22.

of the *Rabinowitz* motor. Accordingly, the proposed modification does not render the claims prima facie obvious.[18]

Proposed combination of *Higashi* and *Rabinowitz* does not teach a superconducting winding

In a winding, a wire guides a current along a coiled path. As a result, the magnetic field generated by the current is reinforced within the volume enclosed by the coiled path. The magnetic field intensity within that volume depends on the number of turns in the winding. To short-circuit the individual turns in the winding would thus undermine the winding's ability to support a magnetic field.

Higashi teaches that

> "a short circuit looped in itself is formed in a squirrel cage rotor comprising a plurality of bar conductor [sic] short circuited by two circular conductors opposite to each other".[19]

The individual bars **4** are therefore shorted together at the two end rings **5**. Thus, the bars **4** extending axially across the rotor are not, as the Examiner appears to suggest, individual turns of a winding. It is therefore apparent that *Higashi* has no teaching of a superconducting winding. Accordingly, the combination of *Higashi* and *Rabinowitz* likewise has no such disclosure.

No motivation to combine *Higashi* and *Rabinowitz*

The Examiner proposes to substitute the squirrel cage rotor assembly of *Higashi* for the entire rotor assembly disclosed by *Rabinowitz*. As motivation for performing this substitution, the Examiner suggests that the resulting motor would be more efficient.[20]

The Examiner has offered nothing beyond a conclusory assertion that removing the *Rabinowitz* rotor assembly and replacing it with the *Higashi* rotor assembly would yield a more efficient motor. In particular, the Examiner has not offered a cogent technical explanation for

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[18] *MPEP* 2143.02, ("If the proposed modification...would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims prima facie obvious") citing *In re Ratti*, 270 F.2d 810 ("suggested combination of references would require a substantial reconstruction and redesign of the elements shown in the [primary reference] as well as a change in the basic principle under which the [primary reference] was designed to operate.").

[19] *Higashi*, col. 1, lines 11-15.

[20] *Final office action*, page 5, "It would have been obvious at the time the invention was made to modify the superconducting electric motor of *Rabinowitz* et al. ('002) and provide it with the rotor assembly disclosed by *Higashi* for the purpose of improving efficiency of the electric motor at start-up and operation).

why the resulting motor would be more efficient. Nor is any such motivation apparent from any teaching or suggestion in the prior art.

Applicant is aware that the efficiency of an induction machine is related to its slip angle.[21] However there is no suggestion that transplanting the *Higashi* rotor assembly into the *Rabinowitz* machine would enable the *Rabinowitz* machine to operate at a smaller slip angle.

Absent any coherent technical explanation for why one of ordinary skill would remove the entire rotor assembly as taught by *Rabinowitz* and replace it with the rotor assembly taught by *Higashi*, the proposed combination of references cannot render the claims prima facie obvious.[22]

Claims 17 and 21

Like claim 1, claim 17 recites a superconducting winding. Claim 21 is a method claim for operating a motor having a superconducting winding. The foregoing arguments with regard to the absence of any teaching or suggestion of a superconducting winding also apply to claims 17 and 21. In addition, the foregoing arguments with regard to the motivation to combine *Rabinowitz* and *Higashi* also apply to claims 17 and 21.

Summary

As set forth above, the section 103 rejection of claim 1 is improper for several independent reasons. First, the cited references do not teach, either singly or in combination, a motor having a superconducting winding and configured to operate in the manner set forth in claim 1. Second, there appears to be no coherently stated motivation for combining these references.

Applicant encloses a $320 check in payment for the fee associated with filing of an appeal brief. No additional fees are believed to be due in connection with the filing of this appeal brief. However to the extent that additional fees are due, or if a refund is forthcoming, please adjust our deposit account 06-1050.

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21 *Woodson and Melcher*, "Electromechanical Dynamics", vol. 1, page 134, John Wiley and Sons, 1968.

22 *Ex parte Clapp*, 227 USPQ 972 (Bd. Pat. App. & Inter. 1986) ("To support the conclusion that the claimed invention is directed to obvious subject matter, either the references must expressly or impliedly suggest the claimed invention or the examiner must present a convincing line of reasoning as to why the artisan would have found the claimed invention to have been obvious in light of the teachings of the references.").

Respectfully submitted,

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Appendix of Claims

1. A superconducting electric motor comprising:

   a rotor assembly including:

   at least one superconducting winding which, in operation, generates a flux path within the rotor assembly; and

   a support member which supports the at least one superconducting winding, the rotor assembly configured to operate

      in a synchronous mode of operation at temperatures wherein the superconducting winding exhibits superconducting characteristics and

      in a steady-state induction mode of operation at temperatures wherein the superconducting winding exhibits non-superconducting characteristics.

2. The superconducting electric motor of claim **1** wherein the rotor assembly includes induction structure for carrying current at levels sufficient to allow the steady-state induction mode of operation.

3. The superconducting electric motor of claim **1** wherein the rotor assembly includes induction structure configured to allow the superconducting motor to generate a starting torque which is at least 50% of the rated torque in the steady-state induction mode of operation.

4. The superconducting electric motor of claim **3** wherein the rotor assembly includes induction structure configured to allow the superconducting motor to generate a peak torque which is approximately twice the rated torque in the steady-state induction mode of operation.

5. The superconducting electric motor of claim **4** wherein at least a portion of the induction structure is spaced from the at least one superconducting winding by a thermal isolation vacuum region.

6. The superconducting electric motor of claim **5** wherein said at least portion of the induction structure spaced from the at least one superconducting winding by a thermal isolation vacuum region includes an electromagnetic shield member.

7. The superconducting electric motor of claim **6** further comprising a cryostat positioned between the thermal isolation vacuum region and the induction structure.

8. The superconducting electric motor of claim **6** wherein said electromagnetic shield member includes a conductive, non-magnetic material.

9. The superconducting electric motor of claim **4** wherein the induction structure includes the support member which supports the at least one superconducting winding.

10. The superconducting electric motor of claim **9** wherein the induction structure further includes an electromagnetic shield spaced from the at least one superconducting winding by a thermal isolation vacuum region.

11. The superconducting electric motor of claim 10 wherein the support member includes a plurality of laminations, each lamination lying in a plane parallel to magnetic field flux lines extending through the laminations during operation of the superconducting electric motor.

12. The superconducting electric motor of claim **1** further comprising:

a stator assembly electromagnetically coupled to the rotor assembly; and

an adjustable speed drive that provides an electrical signal to the stator assembly.

13. The superconducting electric motor of claim **12** wherein the adjustable speed drive provides a signal at a first frequency to the stator to start the superconducting motor in the

synchronous mode of operation and provides a signal at a second frequency, less than the first frequency, to the stator in the steady-state induction mode of operation.

14. The superconducting electric motor of claim **1** wherein the superconducting winding includes a high temperature superconductor.

15. The superconducting electric motor of claim **1** wherein the superconducting winding is a racetrack shaped winding.

16. The superconducting electric motor of claim **1** wherein the support member is formed of aluminum.

17. A superconducting electric motor comprising:

a rotor assembly including at least one superconducting winding comprising a high temperature superconductor, the superconducting winding, in operation, generating flux within the rotor assembly, the rotor assembly configured to operate

in a synchronous mode of operation at temperatures wherein the at least one superconducting winding exhibits superconducting characteristics and

in a steady-state induction mode at temperatures wherein the at least one superconducting winding exhibits non-superconducting characteristics;

a cryostat surrounding the rotor assembly to maintain the at least one superconducting winding at cryogenic temperatures; and

induction structure, which during operation, carries current at levels sufficient to allow the steady-state induction mode of operation of the superconducting electric motor, the induction structure including:

a support member which supports the at least one superconducting winding; and

an electromagnetic shield surrounding the cryostat and the at least one superconducting winding.

18. The superconducting electric motor of claim **17** further comprising:

a stator assembly electromagnetically coupled to the rotor assembly; and

an adjustable speed drive that provides an electrical signal to the stator assembly.

19. The superconducting electric motor of claim **18** wherein the adjustable speed drive provides a signal at a first frequency to the stator to start the superconducting motor in the synchronous mode of operation and provides a signal at a second frequency, less than the first frequency, to the stator in the steady-state induction mode of operation.

20. The superconducting electric motor of claim **17** wherein the support member includes a plurality of laminations, each lamination lying in a plane parallel to magnetic field flux lines extending through the laminations during operation of the superconducting electric motor.

21. A method of operating a superconducting electric motor of the type including a rotor assembly including at least one superconducting winding which, in operation, generates a flux within the rotor assembly, and a support member which supports the at least one superconducting winding, the method comprising:

monitoring the temperature of the at least one superconducting winding;

operating the superconducting motor in a synchronous mode at a temperature wherein the at least one superconducting winding exhibits superconducting characteristics; and

operating the superconducting motor in a steady-state induction mode at a temperature wherein the at least one superconducting winding exhibits non-superconducting characteristics.